



A SURVEY OF VEHICLE TO DRIVER/ENVIRONMENT INTERACTION USING SMARTPHONE

Miss Priyanka Koshti M. E. (E&Tc), Dr. P.H. Zope, Dr. U.S. Bhadade
Department of E&TC Engineering, SSBT's College of Engineering & Technology, Jalgaon.
Maharashtra, India.

Abstract: The object of this proposed work is to present an interaction system implementing a vehicle-to-driver communication and a vehicle-to-environment communication based on a smart phone core and a wireless Bluetooth medium (in the rest of the letter this is indicated as VEDE system). In the literature, the problems of audio and video vehicle-to-driver interaction and remote maintenance have been tackled by several papers mainly focused on automobiles (see, e.g., [3]–[10]). Yet, to the best of our knowledge, these problems seem to be less explored in motorcycles, although the interaction between the vehicle and the driver is different. The objective of this proposed work is to study a system capable of implementing a bidirectional audio interaction with the driver and to provide remote monitoring of the vehicle parameters.

I. INTRODUCTION

The proposed system focuses on the definition and the implementation of an add-on interaction system for motorcycles. The system consists of a vehicle-to-driver and a vehicle-to-environment communication mechanism, which is based on a smart phone core and on a wireless Bluetooth medium. The system is focused to increase the safety level of a motorcycle and it is constituted by a vehicle with a CAN bus, a compact embedded electronic unit implementing a CAN-to-Bluetooth gateway, a smart phone and a Bluetooth helmet. The driver-to-vehicle interaction is based on an audio interaction located at helmet level. The driver-to-environment is represented by communication via the HTTP protocol. The vocal synthesis, the speech recognition, and the gateway to the web server are implemented on the smart phone. To validate the entire system the result is being observed by developing a prototype for the Android platform and tested the performance of this prototype application in a real vehicle while moving. For an example, if a driver requests of motorcycle data (e.g., the request of the water temperature). In this situation, a bidirectional communication is necessary, based on the speech recognition and on the audio synthesis. Finally, the paper covers the hardware architecture, the software architecture and some case-study implementation issues.

II. SURVEY

The system is targeted to increase the safety level of a motorcycle. In the last decade, the research interest in two wheels vehicles has been driven by two main features [1], [2]. On one hand, motorcycles are means for personal mobility with a low environmental impact due to the relatively low weight, and they seem to be extremely promising for the development of electric vehicles. On the other hand, they are responsible for about 20% of road incidents due to a relatively low level of safety. To ensure an improved safety in a motorcycle, this letter proposes to increase the informative interaction between the vehicle and the driver, and to provide a remote monitoring for maintenance purposes. The hands-free audio interaction seems to be the best compromise between safety and the level of information to deliver [2]. Another objective of the letter is to use off-the-shelf pieces of hardware to concentrate the development complexity mainly on the software layer. Under this perspective, a common smart phone can be used. In fact, it usually includes a 3G connection; a wireless communication (e.g., based on Bluetooth and WIFI standards); a relatively large computational capability (supported also by the presence of an operating system); sensing (accelerometers, magnetometers, cameras, etc.); positioning (GPS); and a human-machine-interface (HMI). The architectures completed by a CAN-Bluetooth converter (specifically developed for this application) and an off-the-shelf audio helmet with Bluetooth interface. An electronic system fully developed for this specific application may be adopted; however, it would duplicate the functionalities of a smart phone, which has the clear advantage of being a common device largely spread and usable in several applications. Hence, the smart phone may be viewed intrinsically as a “plug and play” smart gateway. The system so defined present three end-points: an audio system integrated in a helmet with Bluetooth communication, the VCU, which collects the data and controls the vehicle, and a web server for remote monitoring. The gateway between these points is represented by a smart phone.

Hernandez et al. [5] developed a prototype of an on-board unit that allows the driver to communicate with his vehicle, as well as with other available devices (PDAs, cellular, sensor networks, and so on) and with the road infrastructure in order to consume intelligent transport services. In their work, they proposed two new services

based on vehicle-to-infrastructure communications: a) real-time traffic reports, and b) eco-driving support. Also it describes the process of prototyping and testing an in-vehicle embedded system which allows the driver to communicate with his vehicle, with the gadgets inside it (PDAs, cellular, sensor networks, and so on) and with the road infrastructure in order to consume intelligent transport services. The result of the presented work is an on board prototype and two services which have been developed to validate some characteristics of this embedded prototype.

Chen et al. [6] proposed a vehicular Android/OSGi platform that allows diagnosing or managing the system status of a vehicular platform remotely and also to use visual intelligence to continually update their application services based on context awareness without user intervention. Experiments made in a vehicular test bed showed that the proposed Android/OSGi platform has lighter applications and higher performance than a pure Android platform when performing complicated operations.

Al-Ani et al. [7] proposed using an Android-based terminal as a replacement to the vehicle's stereo system to provide a High Fidelity In-Vehicle Infotainment System (IVI). Such system provides informative and interactive material that will extend the driver experience by providing capabilities from a mobile-based operating system.

Cheng et al. [8] proposed an Android-based mobile device platform which provides network management functionalities to guarantee the communication quality. In order to achieve ubiquitous computing, the proposed algorithm supports seamless hand over via effective resource and handover management between heterogeneous networks.

III. HARDWARE ARCHITECTURE

The prototype VEDE system consists of the following elements (see Fig. 3.1)

- A motorcycle natively equipped with a vehicle control unit (VCU), which collects the data from the vehicle, controls the engine, and displays the relevant information on the dashboard. The information is broadcasted over a standard CAN bus between the electronic subsystems in the vehicle.

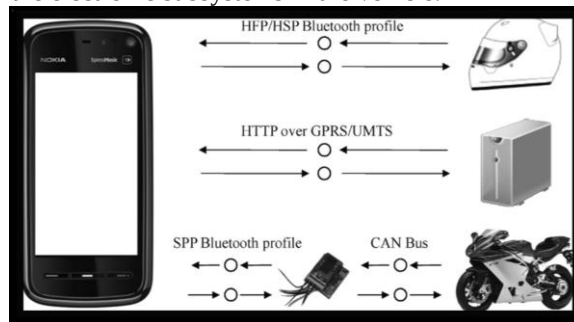


Fig. 3.1. System architecture

- An embedded electronic unit interfaced to the CAN bus of the vehicle, and capable of collecting optional analog and digital signals. The electronic board includes a Bluetooth transceiver.
- A helmet with audio speakers and a microphone. The audio signals may be transmitted over a Bluetooth channel by the embedded transceiver of the helmet.
- A Smartphone equipped with a Bluetooth transceiver and a 3G communication system. The Bluetooth channel is used to establish a communication between the helmet and the CAN-Bluetooth converter. The 3G communication is exploited to transmit and receive data from the web. The mobile device also includes a processor which can handle the audio and vocal synthesis, and the information Management.

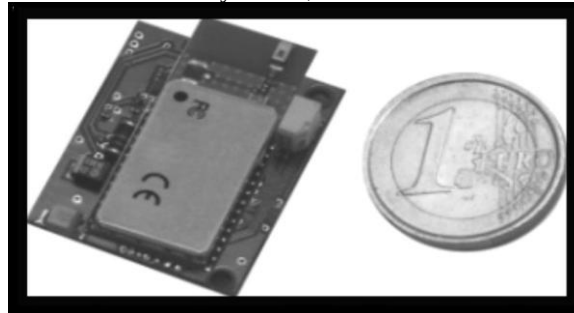


Fig. 3.2. Electronic unit embedded in the motorcycle as a smart CAN-Bluetooth Gateway

A. Embedded Electronic Unit for the CAN-Bluetooth Gateway

The in-vehicle embedded electronic system acts as a gateway between the CAN bus and the Bluetooth channel (in the rest of the letter this is indicated as simply *gateway*). This consists of two modules: one two-layered main board and one Bluetooth add-on. In particular, the embedded electronic system comprises the following components.

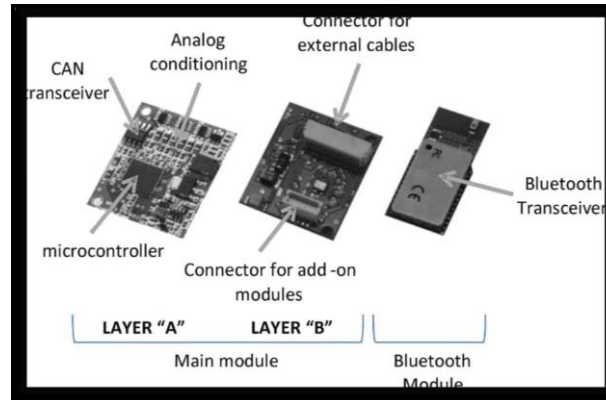


Fig. 3.3. Detailed description of the electronic system embedded in the motorcycle.

- An electronic conditioning for the optional analog and digital acquisition. The analog signals are filtered with second order Bessel low-pass filter.
- A CAN controller set with appropriate baud rate.
- A Bluetooth transceiver with hands-free profile (HFP) and serial-port profile (SPP).
- A ds PIC microcontroller to implement the primary functionalities for acquisition (12-bit ADC) and the CAN-Bluetooth gateway. The presence of a ds PIC makes the embedded electronic system a smart device (see, e.g., [10]).

IV. SOFTWARE ARCHITECTURE

In order to implement the VEDE system, each layer of hardware, as presented in the previous section, needs to be complemented by a corresponding layer of software. The software architecture is represented in Fig. 3.4, which depicts each of the hardware subsystems, and the software interface between them. For the sake of conciseness, it focuses on the driver-to-motorcycle interaction.

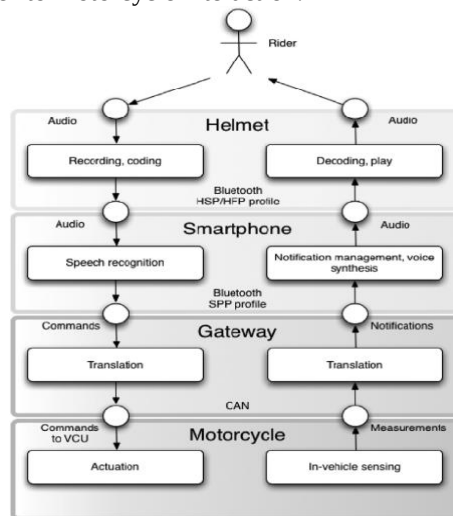


Fig. 3.4. Software architecture representing the driver-to-vehicle interaction.

A. Motorcycle Layer

The motorcycle is natively equipped with a VCU, which manages the vehicle and collects the data. The information interface is constituted by a bus, according to the CAN protocol. The VCU may send messages through it (vehicle sensing), and may act on the basis of the messages that it reads (actuation).

B. CAN-Bluetooth Gateway Layer

The CAN-Bluetooth gateway filters and sends the information over the CAN bus according to the database of accessible information. The gateway also implements a SPP to communicate according to the Bluetooth protocol. The measurements of the vehicle are translated into notifications, and the commands are turned into commands to VCU. At the gateway level, a critical alert may also be recognized on the CAN and then sent to the upper level.

C. The Smartphone Layer

The Smartphone represents the core of the system. The mobile device is characterized by the presence of an operating system that allows the multitasking of the processes (e.g., Windows Mobile, Symbian, and Google Android). The software for the VEDE system may be developed according to the appropriate platform and to the operating system. The interface between the mobile device and the gateway is implemented with the SPP over Bluetooth. The interface between the Smartphone and the helmet is provided by the HFP or, alternatively,

by the HSP over Bluetooth. The software on the Smartphone translates the notification from the gateway into a stream of audio data (voice synthesis). It also turns the speaker data from the helmet into a command to the gateway (speech recognition). The Smartphone also manages the communication to and from the web server (remote point) according to the HTTP protocol (natively embedded in the mobile).

D. The Helmet Layer

We have designed the wireless helmet which will be very useful for the people. By using this system people can drive their vehicle safely. The helmet provides the audio interface to the driver by the means of an integrated headset. The helmet also includes a Bluetooth module implementing the HFP or HSP layer for the interface to the Smartphone. The headset natively records and codes the driver audio commands through the Bluetooth channel. It converts also the Smartphone audio stream into an audio signal for the driver.

V. CASE STUDIES AND EVALUATION ON THE IMPLEMENTED SYSTEM



Figure 3.5: Illustration of the different interacting elements in the scope of the proposed application [10].

The proposed application basically combines two elements vehicle and Smartphone - to achieve a symbiosis between both that is able to improve the effectiveness of emergency services by making accident detection fully automatic. Such as airbag triggering detection, and is complemented with the information gathered by the mobile phone itself, such as GPS information. This is illustrated in figure 3.5. Initially the Smartphone connects device via Bluetooth to retrieve data from the vehicle's bus. The information gained, together with data from other sources (e.g. GPS system) is packed and sent to an emergency services database or to other third parties defined by the user if an accident is detected. This procedure is followed by an automatic call to an operator, which will send an ambulance or other rescue services to the accident location. The application also offers general purpose information to the driver, including gas levels, detection of failures in mechanical elements, extensive engine feedback data, etc [10].

In particular, our solution will rely on the Bluetooth technology to establish a data link between the Smartphone and a GATEWAY Interface. This approach removes the need for any sort of cable, thus making it more robust against car crashes. Since a data communications channel between the Smartphone and an online server is required, it can be established using either the Wi-Fi or the 3G interface. Typically, mobile telephony services, such as voice calls and SMS generation, can also be used. For instance, the system can be configured to send an SMS to our family, establish a voice channel with the emergency services, and send detailed accident information, including impact speed and current GPS position, to a special purpose server. This way, all the entities involved in the process may obtain all the information considered relevant.

We developed a prototype for the Android platform to validate our approach, and tested the performance of this prototype application in a real vehicle while moving. Experimental results show that, although the limited bandwidth of the CAN bus limits the amount of sensors that can be simultaneously monitored, critical data can still be retrieved accurately and timely since the number of critical sensors is low. Concerning accident detection, we find that the whole process takes less than three seconds, including reading critical data from the vehicle's bus, delivering information about the accident through both e-mail and SMS, and finally starting an emergency call.

VI. RESULT

Table: 4.1 Channel usages with respect to the system throughput

Channel	Channel throughput [bit/s]	System throughput [bit/s]	Usage [%]
CAN	542372	102400	18.9
Bluetooth	102400	102400	100

For test purposes, the system has been implemented in a hyper sport motorcycle developed by MV Augusta (Italy). This vehicle Includes a CAN bus with a baud rate of 500 kb/s. The motorcycle has been equipped with the embedded electronic system presented in Section II and developed by E-SHOCK (Italy). The helmet is a Bluetooth helmet with a HFP produced by Dainese (Italy). Two smart phones have been used: a Nokia 5800 with Symbian as operating system and an HTC Touch Cruise with Windows Mobile as operating system. The software of the architecture has been adapted according to the operating system of the mobile device. Interestingly enough the rest of the architecture is not phone-dependent, so the mobile device may be viewed as a plug and play part of the overall architecture. The general system discussed earlier consists of the following operational modes.

- Driver request of motorcycle data (e.g., the request of the water temperature). In this situation, a bidirectional communication is necessary, based on the speech recognition and on the audio synthesis.
- Push notification of motorcycle alert (e.g., the notification that the direction indicator is on). The gateway recognizes the CAN message of the indicator on, and it sends a notification to the upper level (the Smartphone) and finally to the driver.
- Driver sends commands (e.g., turn off the direction indicator). The driver states a command in the microphone which is translated through the communication chain toward the vehicle control unit.
- Data analysis for diagnostic and maintenance (e.g., the odometer reports a mileage that requires a mechanical revision of the vehicle). In this situation, the data from the vehicle are sent to the web server via a HTTP communication and collected. On the server, a diagnostic may be performed and if necessary, it may be notified to the driver. Note that in this situation a data history is stored in the remote end-point of the system.

VII. CONCLUSION

Since a relatively low development effort is required from the motorcycle manufacturer and none from the helmet manufacturer, once the CAN dictionary of the motorcycle is defined, the system may be plugged and played. This makes the architecture interesting for practical applications and product development. It is worth noticing that the proposed architecture may be seen as a platform for the software implementation of several added value services.

VIII. FUTURE SCOPE

Current research efforts aim at developing solutions to enable a future where the networked vehicle plays central roles in our lives, offering countless possibilities in sectors such as security, publicity, entertainment and commerce. As future work we plan to further validate our application in real crash tests, and to develop an enhanced emergency services server that is able to integrate the information automatically delivered by the vehicle with information manually introduced by the operator, thereby achieving a detailed accident characterization and management service. Combination of two elements vehicle and Smartphone - to achieve a symbiosis between both that is able to improve the effectiveness of emergency services by making accident detection fully automatic.

IX. REFERENCES

- [1] M. Pieve, F. Tesauri, and A. Spadoni, "Mitigation accident risk in powered two wheelers domain: Improving effectiveness of human-machine interface collision avoidance system in two wheelers," in *Proc. 2nd. Conf. Human Syst. Interact.*, Catania, Italy, May 21–23, 2009, pp. 603–607.
- [2] E. D. Bekiaris, A. Spadoni, and S. I. Nikolaou, "SAFERIDER project: New safety and comfort in powered two wheelers," in *Proc. 2nd Conf. Human Syst. Interact.*, Catania, Italy, May 21–23, 2009, pp. 600–602.
- [3] A. Barón and P. Green, *Safety and Usability of Speech Interfaces for In-Vehicle Tasks While Driving: A Brief Literature Review*. Tech. Rep. UMTRI-2006-5, 2006.
- [4] M. Cellario, "Human-centered intelligent vehicles: Toward multimodal interface integration," *IEEE Intell. Syst.*, vol. 16, no. 4, p. 78, Jul. 2001.
- [5] U. Hernandez, A. Perallos, N. Sainz, and I. Angulo, "Vehicle on board platform: Communications test and prototyping," in *Intelligent Vehicles Symposium (IV)*, 2010 IEEE, pp. 967–972, 2010.
- [6] M.-C. Chen, J.-L. Chen, and T.-W. Chang, "Android/OSGi-based vehicular network management system," *Elsevier Computer Communications*, vol. 34, no. 2, pp. 169–183, 2011.
- [7] Tarik Al-Ani, Tony Savarimuthu, and Maryam Purvis, "Android-based in-vehicle infotainment system (aivi)," in *Information Science Postgraduate Day 2010*, (Dunedin, New Zealand), pp. 51–52, October 2010.
- [8] Y.-H. Cheng, W.-K. Kuo, and S.-L. Su, "An android system design and implementation for telematics services," in *Intelligent Computing and Intelligent Systems (ICIS)*, 2010 IEEE International Conference on, vol. 2, pp. 206–210, 2010.
- [9] C. Spelta, V. Manzoni, A. Corti, A. Goggi, and S. Savaresi, "Smartphone-based vehicle-to-driver/environment interaction system for motorcycles," *Embedded Systems Letters, IEEE*, vol. 2, no. 2, pp. 39–42, 2010.
- [10] "Providing Accident Detection in Vehicular Networks Through OBD-II Devices and Android-based Smartphone's" Jorge Zaldivar, Carlos T. Calafate, Juan Carlos Cano, Pietro Manzoni, 5th IEEE workshop on user mobility and vehicular networks, on move 2011, Bonn.
- [11] "An Optimal Driving System by Using Wireless Helmet" K. Rambabu¹, B. Premalatha², C. Veeranjanyulu, ISSN: 2278 – 7798 *International Journal of Science, Engineering and Technology Research (IJSETR)* Volume 2, Issue 9, September 2013.